CORRESPONDENCE/MEMORANDUM

DATE: April 18, 2002

TO: NR 445 Technical Advisory Group

FROM: Joe Thompson, Bureau of Air Management

SUBJECT: Review of Stationary Diesel Particulate Matter Emission Control Technology

In an effort to protect public health from the detrimental effects of stationary source diesel particulate matter (PM) emissions, the WDNR has developed preliminary emissions standards at 0.10 g/bhp-hr for engines with an engine size of 100-750 bhp, and 0.03 g/bhp-hr for engines larger than 750 bhp. These emission standards prospectively go into effect in 2006 and would apply to engines combusting 40,000 gallons or more of fuel oil per year. The preliminary determination is based on review of available literature, which is discussed in more detail below.

Stationary Diesel Particulate Matter Emission Control Technologies

Two primary strategies available to limit PM emissions from diesel engines are minimization of diesel fuel sulfur content and application of control technologies.

PM control technologies widely available for retrofit of diesel engines include diesel particulate filters (DPF), diesel oxidation catalysts (DOC), and selective catalytic reduction (SCR). Each technology has varying effects on PM reductions depending upon engine size and use patterns, fuel sulfur level, control technology material composition, and engine maintenance techniques and systems. Additional PM control methods are available, and include technologies such as fuel borne catalysts (FBC), exhaust gas re-circulation (EGR), and advanced engine control systems, amongst others. These technologies can be combined in certain circumstances to further enhance PM emission reductions.

The WDNR undertook a survey of available PM control technology sources in an attempt to determine the emission reduction capabilities of various technologies.

Literature Review Process

The department initiated the diesel PM control review process by identifying likely sources of information, such as government agencies, control product manufacturers, diesel technology non-governmental organizations, academic literature, and industries reliant on diesel technology. Preliminary research within each field allowed identification of key resources based on accessibility of public data, and perceived information quality and reliability. Once key resources were identified within each field, additional efforts were made to acquire reports, studies, research initiatives, fact sheets, and other data sources. Individuals within key organizations were contacted for guidance and information procurement purposes.

Following a lengthy information acquisition and dissemination process, relevant data sources were reviewed to assess percent reduction and emission standard levels achievable with each type of PM emission control technology. A spreadsheet was created to summarize percent reductions, emission levels, fuel sulfur content, testing methods, and limitations of control technology.

The department parsed available data by technology type in an attempt to gain a broader understanding of the capability of each technology species across different source and application types. Generalized findings were based on the interpretation of grouped data.

General Findings

Control Technology PM Percent Reduction Capabilities

Diesel PM control technologies have different capabilities as expressed in percent reductions versus baseline (non-control) emissions. In Table 1 below, the department compiled reduction rates identified in available literature in an attempt to summarize the percent reductions attributable to control technologies. The summarized data sources are available in the attached works cited document in Appendix A.

Table 1: PM Emission Reductions Achievable with Control Technologies

	Minimum PM Emission Reduction (%)	Average PM Emission Reduction (%)	Maximum PM Emission Reduction (%)
DPF	50	81	99
SCR	22	37	50
DOC	16	35	60
All Technologies	16	57	99

It is important to note that the sources consulted used different brands of technology, technology combinations, and measurement methods to determine the percent reduction data. These figures are extremely conservative, giving equal weight to out-dated technologies that are not typically applied. The figures above also ignore the use rates of available technology.

Control Technology PM g/bhp-hr Emissions Rate Capabilities

Specific information relating to g/bhp-hr emissions standards achievable through application of PM control technologies is difficult to obtain. The department located two primary sources of specific emission levels achievable through the application of control technologies. Testing methodologies and results are described below. Each source is also included in the works cited document found in Appendix A.

1. **California Air Resources Board (CARB) –** Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles, Appendix IX.

   The California Air Resources Board conducted a two-phase review of products and technologies that reduced PM emissions from diesel engines. Phase one consisted of the creation of product summaries primarily based on information submitted by control technology manufacturers. In phase two, the CARB developed evaluation criteria for technologies where emission test information was available. The control technology manufacturers were responsible for providing adequate emission test data, and were not required to follow any particular testing methodology. Several methods were used, including the Federal Test Procedure Transient, European Stationary Cycle (OICA), ISO 8178 C1, and several multi-mode steady-state tests, in addition to other methodologies. Control technologies were tested on a wide range of applications, including buses and stationary sources. The CARB data for the three common control technologies (DPF, DOC, and SCR) were compiled in a spreadsheet and averaged across technology type, and are summarized in Table 2 below.

Table 2: PM Emission Rates Achievable with Control Technologies - CARB

	Lowest PM Emission Rate (g/bhp-hr)	Average PM Emission Rate (g/bhp-hr)	Highest PM Emission Rate (g/bhp-hr)
DPF	.003	.05	.2
DPF w/ FBC	.009	.017	.032
SCR	.04	.09	.24
DOC	.043	.14	.521
All Technologies	.003	.07	.521

2. **Manufacturers of Emission Controls Association (MECA)** – Demonstration of Advanced Emission Control Technologies Enabling Diesel-Powered Heavy-Duty Engines to Achieve Low Emission Levels

   MECA and the Southwest Research Institute (SwRI) sponsored a test program to evaluate diesel control technologies in 1999. A 1998 12.7 L Detroit Diesel Corporation 400 horsepower, Series 60 engine was selected to represent a typical heavy-duty on-road diesel engine. Control Technologies were evaluated using two-fuel sulfur levels, 54 and 368 parts per million (ppm) in an effort to identify effects of fuel sulfur content on control efficiency. The emissions levels were determined using the US Federal Test Procedure (FTP) and a 13-mode steady state test derived to investigate emissions outside of the FTP during steady state operation. The steady state test combined 13 different engine rpm levels and torque percentages, with particulate collected for thirty minutes for each steady state mode. Additional testing was performed using the European Steady Cycle Test procedure. PM was collected using a set of 90-mm Pallflex filters that were weighed before and after the test cycle.

   The results of the MECA tests are summarized on Tables 3 and 4 below, and show considerable variability between technology types and fuel sulfur levels.

Table 3: PM Emission Rates Achievable with Control Technologies – MECA 54 ppm Sulfur Fuel

	Lowest PM Emission Rate (g/bhp-hr)	Average PM Emission Rate (g/bhp-hr)	Highest PM Emission Rate (g/bhp-hr)
DPF		.008	
DPF w/ EGR		.05	
DOC	.042	.0435	.045
DOC w/ FBC		.036	
SCR			
SCR w/ DOC		.042	
SCR w/ DPF			
All Technologies		.0345	

Note: If average emission rate is the only value for a technology type, there was only one observation (MECA didn't give a range in these cases).

Table 4: PM Emission Rates Achievable with Control Technologies – MECA 368 ppm Sulfur Fuel

	Lowest PM Emission Rate (g/bhp-hr)	Average PM Emission Rate (g/bhp-hr)	Highest PM Emission Rate (g/bhp-hr)
DPF	.016	.019	.022
DPF w/ EGR	.01	.03	.05
DOC		.05	
DOC w/ FBC		.042	
SCR		.062	
SCR w/ DOC		.05	
SCR w/ DPF	.002	.006	.01
All Technologies	.002	.042	.05

Note: If average emission rate is the only value for a technology type, there was only one observation (MECA didn't give a range in these cases).

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